Medical Evaluation of Nutritional Status*

Roentgen Appraisal of Development†

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THE present report is based upon assessments of roentgenograms of three skeletal areas—hand, elbow, and hip—of 180 boys in a private high school and 292 boys in a public high school. These boys form a part of the total group of approximately 3,000 adolescent boys and girls. The purpose, methods, and subjects of the study have been described in a previous report from the coöperative investigation. Further studies of the roentgenograms of the entire group, and of the technic of assessment are in progress.

Nutritional requirements during childhood differ at different ages, and this age variation is always taken into account in estimating requirements or in defining criteria for the interpretation of nutritional tests and measurements. Growth, as measured by changes in body size and weight, is one important aspect of age variation, and the reciprocal relation between growth and nutrition is well recognized. During the period of growth, marked impairments of nutrition will diminish, or even abolish for a period, increments of stature and breadth as well as of weight. Conversely, the rate of growth itself is a determinant of the nutritional requirements of the individual child and a factor influencing the manifestations of nutritional deficiency diseases.

Differentiation of tissues and organs is another aspect of change occurring with age. Such change is termed developmental, and while related to growth in size, it requires separate consideration. Especially in the adolescent period, the age span of subjects of the present study, considerable variation in development exists at each chronological age. This variation is apparent even on simple inspection and classification of external features of development. Variation in development may well be related to nutritional requirements and to the individual levels manifested in response to specific nutritional measurements, such as hematological and some chemical determinations. If such a relationship exists, classification of subjects by age alone, or perhaps

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* From a coöperative investigation by the U. S. Public Health Service, Division of Public Health Methods; the Cornell University Medical College, Department of Public Health and Preventive Medicine and Department of Pediatrics; the Milbank Memorial Fund; and the New York City Department of Health.

The coöperating agencies have been assisted in carrying out this investigation by the Work Projects Administration for the City of New York, Official Project No. 65-1-97-21 W.P. 24, "Medical Evaluation of Nutritional Status."

† Based upon a report read before the Food and Nutrition Section of the American Public Health Association at the Sixty-ninth Annual Meeting in Detroit, Mich., October 8, 1940.

even by age and body measurements, may fail to reveal possible trends in nutritional measurements which could be identified with classification of subjects according to an estimate of developmental status.

The rating of development on the basis of external anatomical features made by the examining physicians in this study appeared to permit only a broad classification of subjects. In an effort to secure a more precise rating of development, therefore, roentgen studies of skeletal maturation were made.

In the adolescent age period, clearly marked qualitative changes are present in the ends of the shafts of the bones and in their related epiphyses up to the point of complete skeletal maturity. In order to describe the developmental status and developmental progress of a group of children, it is necessary that these stages of skeletal change be placed in a series, of which each film represents a successive step in skeletal maturation. A number of such series have been described, among them those of Rotch (1907), Hellman (1928), Shelton (1931), Flory (1936), and Todd (1937). Todd's *Atlas of Skeletal Maturation. I. Hand,* comprises 35 films of female hands and 40 films of the male series. Standards were also prepared by Todd and his associates for the shoulder, elbow, hip, knee, and foot, but have not been published.

Some investigators have chosen to rely upon the appraisal of a single skeletal area as a measurement of development. However, progress in different regions of the skeleton may not be uniform. In the present investigation, roentgenograms of each of three areas—hand, elbow, and hip—were secured from each subject to permit a study of skeletal maturity in several areas of the skeleton. They were assessed against the standards of Todd and his coworkers. Each of the standards is described as representing the median film from a series of children

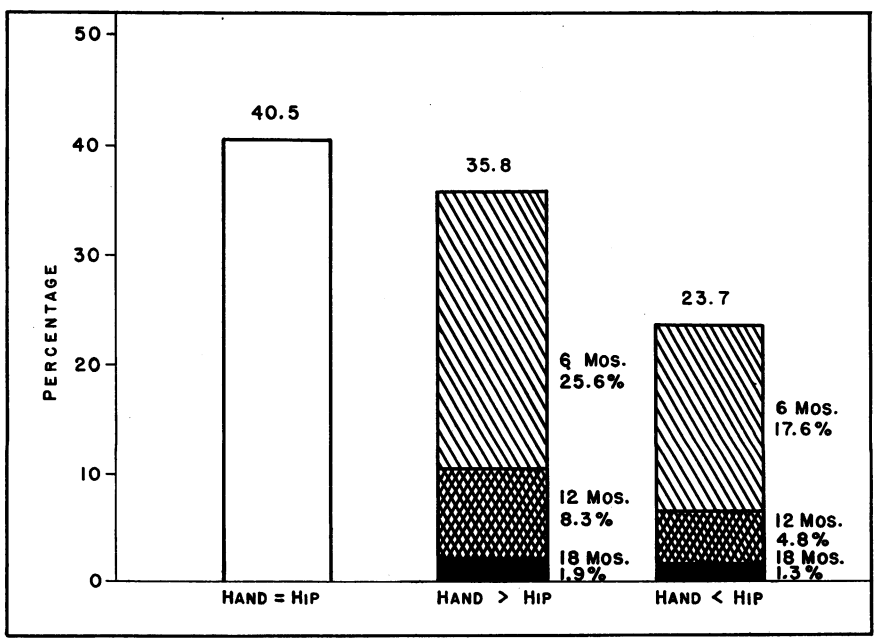

FIGURE 1—The Relation between Skeletal Age of Boys Based upon the Hand Assessment and Skeletal Age Based upon the Hip Assessment

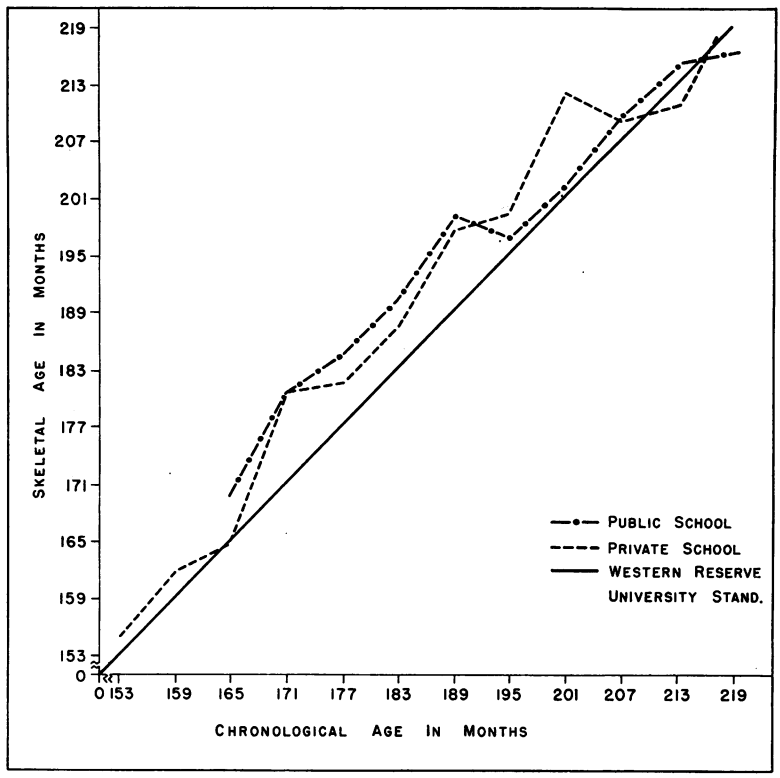

FIGURE 2—The Median Skeletal Ages by Chronological Age Classes of Boys from a Private and a Public School

whose chronological ages fall within a 6 month age span. Each film in the series is numbered and is referred to an age equivalent which is the midpoint of the 6 month chronological age span of the children from whose roentgenograms the standard was chosen. With perhaps some reservation, therefore, it may be said that the standards represent the median skeletal "age" for each chronological age group, of presumably healthy, well developed children of Cleveland.

The assessments of skeletal development by each of the three areas studied were compared with each other. Figure 1 illustrates the relation of skeletal age according to the hand assessment as against that based upon the hip assessment. It will be seen that the two ratings so obtained correspond within a 6 month span in approximately 40 per cent of the cases, but that differences of 6 and 12 months occur in 43 per cent and 13 per cent respectively, and in a small proportion of cases even greater differences are present. The same is true when the relationships between hand and elbow and between elbow and hip are examined. The importance of these differences is a subject for further detailed investigation, and it is sufficient at this time merely to mention them. In the subsequent figures, the skeletal age will refer to the mean derived from the age equivalent in months of the three areas.

The median skeletal ages of each 6 months chronological age group of the boys from the private and public schools are presented in Figure 2, in

which the age equivalents of the Western Reserve University standards are indicated by the continuous line. The number of cases at each year of chronological age is shown in Table 1. The

TABLE 1

Number of Cases in Each Year of Chronological Age

Age Years and Months	*Public School*	*Private School*
Less than 13	4	28
13 – 13–11	13	36
14 – 14–11	31	31
15 – 15–11	74	30
16 – 16–11	84	28
17 – 17–11	59	19
18 and over	27	8

medians of the public and private school groups approximate each other fairly closely. When compared with the age equivalents of the Western Reserve standards, the New York children appear to represent a somewhat greater degree of skeletal advancement for most chronological ages, although the differences are not great.

There is a considerable degree of variability of skeletal ages in each chronological age group for both the private and public school pupils. The range of skeletal age, for most chronological ages spreads over a span of 4 years. Figure 3 presents the percentage of children in each school with skeletal age corresponding to chronological age within a 6 month span, and the percentage of those with differences greater than 6 months. Those with differences are divided into two groups, one in which the skeletal age is greater than the chronological, and another in which the skeletal age is smaller than the chronological. Differences of 1, 2, and more than 2 years are indicated. It will be seen that approximately one-

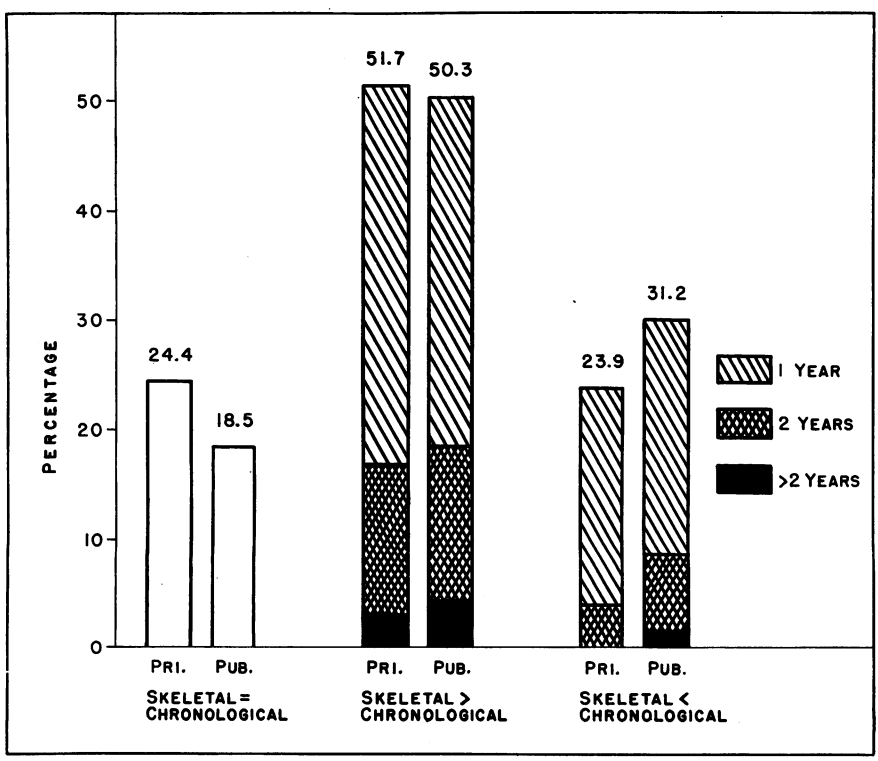

FIGURE 3—The Relation of Skeletal and Chronological Age of Boys in a Private School and a Public School

fourth of the pupils showed correspondence of skeletal and chronological age, that in approximately one-fourth skeletal age was less than chronological age, and in approximately one-half the skeletal age was greater than the chronological age. Somewhat more children in the private school were classed as having skeletal ages corresponding to their chronological ages than in the public school group, and the equivalent difference between the two is accounted for largely by the greater number of children in the public school group whose skeletal ages fall below their chronological ages.

SUMMARY

Assessment of skeletal development against standards of the Western Reserve University was carried out in conjunction with a study of nutrition. Roentgenograms of hand, elbow, and hip of each individual were studied. The degree of skeletal development in the three skeletal areas corresponded closely in approximately 40 per cent of cases, and in about the same proportion differences of 6 months appeared. In a small proportion there were differences between the areas of one or more years of skeletal development.

The median skeletal ages for each chronological age class, based upon the mean of all three areas, did not appear to differ markedly in the private and the public school groups. The median skeletal ages of both of these groups of adolescents in the New York study were somewhat greater at most chronological ages than the median skeletal ages (standard age equivalents) of the Cleveland children from whom the standard roentgenograms were selected.

A larger percentage of the private school boys than the public school boys were classed as having skeletal ages corresponding to their chronological ages, and the equivalent difference between the two was accounted for largely by the greater number of cases in the public school whose skeletal ages fall below their chronological ages.

These studies, and others now in progress including the entire series of roentgenograms, are preliminary to the use of developmental status as one basis of classification of values for certain nutritional test methods.

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NOTE: We wish to express our appreciation to H. G. Fischer & Co., 131 E. 23d St., N. Y., for lending us the portable x-ray unit with which all roentgenograms in the private school were taken.